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FEDERAL EXPERIMENT STATION IN PUERTO RICO
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

REPORT OF THE FEDERAL EXPERIMENT STATION IN PUERTO RICO 1951

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AGRICULTURAL RESEARCH ADMINISTRATION
OFFICE OF EXPERIMENT STATIONS

FEDERAL EXPERIMENT STATION IN PUERTO RICO

MAYAGUEZ, P. R.

Administered by the Office of Experiment Stations, Agricultural Research Administration
United States Department of Agriculture

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[1] In cooperation with the Government of Puerto Rico.

FEDERAL EXPERIMENT STATION IN PUERTO RICO

of the

UNITED STATES DEPARTMENT OF AGRICULTURE

Mayaguez, Puerto Rico

Washington 25, D. C. December 1951

REPORT OF THE FEDERAL EXPERIMENT STATION IN PUERTO RICO, 1951

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INTRODUCTION

The station's program continued to place emphasis on basic investigations and on the more fundamental phases of agricultural research. Most of these investigations were concerned with problems and crops of strategic and economic importance to the continental United States. A number of projects were centered particularly on the improvement of Puerto Rican agriculture.

Owing to a reduction in appropriation, it was necessary to make certain adjustments of programs during the year. The agronomic phases of the insecticidal project were curtailed considerably and the major effort was directed toward the chemical extraction and isolation of the active principles in some of the tropical plants known to have insecticidal properties.

The work with drug crops, particularly cinchona, was reduced, but new work was undertaken on other drug crops, particularly plants that might be possible sources of the drug cortisone.

Work in the field of food production was concerned primarily with cooperative projects being conducted on papaya and tomato, and in breeding sweetpotatoes for the continental United States.

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The entomological program was largely discontinued because of lack of funds to carry out the work.

Important advances were made in the field of weed control, particularly fundamental studies on the action of herbicides on plants.

The cooperative program on the improvement of forage grasses and legumes was expanded to include studies on toxicity and palatability to animals. Survey of forage diseases in Puerto Rico was completed and a paper on this subject is in preparation.

The accounts on pages 4–34 summarize briefly the results obtained during the year. A more detailed account of the experimental results is reported in the publications listed on pages 35–36.

PERSONNEL

The following changes occurred in the Federal staff during the year. Richard H. Hageman resigned as chemist on September 30, 1950, to take up graduate studies at the University of California. Caleb Pagán Carlo began a year's leave of absence on December 13, 1950, to attend graduate school at the University of Oklahoma. Harold K. Plank, entomologist, transferred to the Bureau of Entomology and Plant Quarantine in San Juan on February 28, 1951. Murrell P. Morris, formerly assistant professor of chemistry at Louisiana College in Natchitoches, La., joined the staff as chemist on September 24, 1950. Dr. Carl D. La Rue, professor of botany, on sabbatical leave from the University of Michigan, spent February to June 1951 at the station conducting investigations on experimental morphology.

The following changes occurred during the year in personnel employed with funds provided by the Government of Puerto Rico. Filiberto Montalvo Durand, agronomist in charge of bamboo, was called to active duty with the Armed Forces on August 31, 1950. Pedro Sostre Maysonet, appointed to fill the vacancy on December 11, 1950, resigned May 12, 1951. Eugenio Cabanillas was appointed agronomist on July 1, 1950.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

Funds in the amount of $44,065 were appropriated by the Government of Puerto Rico to the Federal Experiment Station for carrying out cooperative experimental work on agricultural problems of particular local interest. These investigations included studies on vanilla, spices, weed control, essential oils, tomato and papaya breeding, and bamboo.

The Experiment Station of the University of Puerto Rico and the Federal Station continued to maintain close relations. The cooperative tomato, papaya, and forage improvement projects were continued. Through conferences of staff members, the two stations maintained a well-coordinated program. The Federal Station provided office, laboratory space, and land facilities for the experimental work with coffee being conducted by the Insular Station at Mayaguez.

The College of Agriculture and Mechanic Arts of the University of Puerto Rico, located adjacent to the station, utilized station facilities for their field trips and demonstrations. Several students were en-

rolled in practice courses of study and research at the station in the field of chemistry.

The Extension Service of the University of Puerto Rico was extremely helpful in the distribution of plant material to farmers, and in the dissemination of technical information developed by the station.

The Forest Service continued to make land available to the station at Toro Negro, Maricao, and Guanica, for the testing of various tropical plants.

The Puerto Rico Industrial Development Co. cooperated with the station through the distribution of cured bamboo culms for industrial purposes.

A number of cooperative projects were carried out in cooperation with other bureaus and agencies of the Department. The work with cotton, started 2 years ago in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Texas Agricultural Experiment Station, was continued. A number of selfings of tropical and subtropical cottons of potential value for improving domestic varieties were made. An investigation on the improvement of sweetpotatoes and the introduction of varieties resistant to fusarium wilt was also carried out in cooperation with the same bureau. Preliminary trials with various species of *Strophanthus* were started in cooperation with this bureau.

The Bureau of Entomology and Plant Quarantine was provided with office and laboratory space for one of its plant quarantine inspectors. Office space was also provided for the cooperative inspector of the Insular Plant Quarantine Service, and for the Soil Conservation Service.

Close relations were maintained with the Office of Foreign Agricultural Relations of the Department in the exchange of technical information and plant material. The cooperative bamboo experiments initiated 2 years ago in collaboration with F. A. McClure, Field Service Consultant on Bamboo for the Office of Foreign Agricultural Relations, were continued.

Individuals and various companies too numerous to mention have extended cooperation in many ways. Through the cooperation of many agencies and individuals scattered throughout the world, many additions have been made to our extensive collection of tropical plants.

PHYSICAL PLANT IMPROVEMENT

A new 2½-inch galvanized water pipe was laid from the Las Mesas Reservoir to the station water storage tanks, a distance of about 3 miles. The old water line has been in place about 23 years, and is beginning to deteriorate.

The storage capacity of the station water tanks was increased from 2 million to nearly 4 million gallons by the construction of a 1-foot-thick concrete wall 6 feet above ground level, on top of the existing wall.

An incinerator for burning garbage and other refuse was installed in the new concrete warehouse building constructed last year. In the same building a steam boiler was installed to supply steam to the

dairy house and sterilization room. A walk-in refrigerator of 80-cubic feet capacity with 15 cubic feet of freezer space was put into operation.

One of the large station greenhouses was reconditioned. Rotten timbers were replaced with treated lumber and a new glass roof was laid.

A new and more convenient plant-distribution area was established. The area was enclosed with an attractive bamboo fence and gate.

A pit with hydraulic lift for greasing and washing station cars was constructed in the new garage and maintenance area.

An interoffice telephone system was installed which greatly facilitates station business and interoffice communication.

INSECTICIDAL CROP INVESTIGATIONS

Derris Flowering. R. H. Hageman.

For the first time at this station all three varieties of *Derris elliptica* (Wall.) Benth—Changi 3, St. Croix, and Sarawak Creeping—flowered simultaneously, and some seed were produced. Germination occurred in 60 percent of the St. Croix seed, 25 percent of the Sarawak Creeping, and 3 percent of the Changi 3 seed. Trellised plants were much more vigorous than untrellised ones. They flowered for the first time last year and again this year, whereas none of the untrellised plants have blossomed. Since it is known that light plays an important role in floral production and that trellising the plants exposes a greater leaf area to sunlight, trellising may induce the plant to bloom.

Evaluation of Derris and Lonchocarpus. C. Pagán and R. H. Hageman.

A preliminary study of plants of the Sarawak Creeping variety of *Derris elliptica* growing at the station revealed several high-rotenone clones. A second set of 50 plants selected at random from the same location was dug and analyzed to determine whether a similar segregation could be obtained. The plants were numbered and cuttings were made for maintaining propagation stock of the best clones.

The roots were evaluated on the basis of their total chloroform extractives. Many of the plants were above average in toxic constituents (20 to 30 percent total chloroform extractives). Nine plants of the group had exceptionally high rotenone content (25 to 30 percent total chloroform extractives).

In the 1949 report (p. 6) equations were presented for estimating rotenone equivalent (toxicity) from total chloroform extractives in derris roots. No data, however, are available on this relationship for roots of *Lonchocarpus*. Recently the Tingo Maria station in Peru[1] sent 9 root samples of *Lonchocarpus urucu* A. C. Smith for chemical and biological assay.

A highly significant relationship was found between total chloroform extractives and rotenone equivalent in *Lonchocarpus utilis*. A nonsignificant value was obtained in the species *L. urucu*, probably due to the limited number of samples and the narrow range of the values compared. When both species were considered together the correlation was highly significant with a value for R of 0.920. This

[1] In cooperation with the Technical Collaboration Branch, Office of Foreign Agricultural Relations, U. S. Department of Agriculture.

suggests a similar relationship between total chloroform extractives and toxicity in both species. The equation obtained with *L. utilis* alone was practically the same for both *L. urucu* and *L. utilis*. Although one equation fits both species, *L. urucu* was found to be definitely less toxic than *L. utilis*.

Two sets of samples from the second and third harvest of an agronomic evaluation experiment in Nicaragua were received for chemical and biological assay.[2] Four varieties of *Derris elliptica*: Changi 1, Changi 2, Changi 3, and Sarawak Creeping, and the variety Sarawakensis of *D. malaccensis* (Benth.) Prain were represented in the samples. The data obtained from the second harvest were in very close agreement with values obtained last year. The clones of Changi 1 and Changi 3 again were about the same in chemical and toxic constituents. These two varieties were superior to the Changi 2 which in turn was much better than the Sarawak Creeping variety. The Sarawakensis variety of *D. malaccensis* ranked last in both evaluations. In general, the percentages of chemical constituents showed a slight increase over the preceding harvest.

Analysis of the third harvest showed a drop in total chloroform extractives (T. C. E.) in all varieties. This drop may be due to a proportionally greater increase in dry weight than in rotenone content. A similar trend was observed in rotenone content, with the exception of the varieties Sarawakensis and Changi 1, which showed a negligible increase. As a result of these new data the new rank is as follows: Changi No. 1 was superior to Changi No. 3 which in turn was much better than Changi No. 2. The Sarawak Creeping variety was fourth in rank, followed by Sarawakensis which has been the poorest in all three harvests.

AGRONOMIC STUDIES. R. H. Hageman, C. Pagán, and A. J. Loustalot.

An experiment was carried out to determine the effect of altitude on the growth and insecticidal value of *Derris* and *Lonchocarpus*. Plantings of two varieties of *Derris elliptica*, Sarawak Creeping and MG-clone 8, and one of *Lonchocarpus* sp. were made at four elevations in Puerto Rico located as follows: Las Ochenta, Mayaguez, 80 feet above sea level; Las Mesas, Mayaguez, 1,200 feet; Maricao, 2,400 feet; and Toro Negro, 3,300 feet. After 2 years' growth the plots were harvested, and the data on yield and chemical composition were obtained.

The percentage of insecticidal constituents in the roots of all varieties decreased consistently and significantly as altitude increased. The MG-clone 8 had the highest percentage of insecticidal constituents at all locations. The T. C. E. percentage of this variety varied from 18.17 percent at Las Ochenta to 7.55 percent at Maricao. The percentage of insecticidal constituents in *Lonchocarpus* roots grown at Las Ochenta was greater than that in Sarawak Creeping grown at the same location but at Las Mesas and Maricao, Sarawak Creeping roots had as much or more insecticidal value as *Lonchocarpus*. The variety Sarawak Creeping was adapted to the widest range of altitudes. Although it grew best at altitudes ranging from 1,200 feet to 2,400 feet above sea level *Lonchocarpus* sp. was the most exacting

[2] See footnote 1, p. 4.

in its environmental requirements, the best growth being made at Las Mesas at 1,200-feet elevation. But even there the growth was only fair compared to the other two varieties. MG-clone 8 made fair to excellent growth in the altitude range of 80 to 2,400 feet. However, the best growth was made at 1,200-feet elevation and little or no growth was made at 3,300 feet.

Although the highest percentages of insecticidal constituents in all varieties occurred at the lowest elevation, it should be borne in mind that in calculating the yield of insecticidal value per acre, the factor of root yield must be taken into consideration. For example, the percentage of T. C. E. of MG-clone 8 grown at Las Ochenta was 18.17, whereas that of the same variety grown at Las Mesas was only 13.98. However, the yield of dry root at Las Ochenta was only 159 grams per plant compared to 309 grams for the MG-clone 8 grown at Las Mesas. The yield of T. C. E. per plant (percent T. C. E. × gm. dry weight per plant) at Las Ochenta was only 28.9 gm. as compared to 43.2 gm. for the MG variety grown at Las Mesas.

The data obtained in this experiment show that differences in elevation and the variation in temperature and other environmental factors that accompany it have a marked influence on the survival and growth of these three varieties of insecticidal plants. The data also show that as the elevation increases the percentage of insecticidal constituents in the roots decreases.

PHYSIOLOGICAL STUDIES. R. H. Hageman and C. Pagán.

An experiment was conducted to determine the effect of four controlled temperatures on the respiration of derris roots and their rotenone and carbohydrate content. Cuttings of *Derris elliptica* were selected, top pruned, and transferred to individual 5-gallon glass respiration chambers. Four of the respiration chambers, each containing one rooted cutting, were submerged in each of four constant-temperature water baths.

Temperature treatments were initiated in November 1947 after the plants had become well established. Automatic cooling and heating equipment maintained the four separate water baths at 60°, 70°, 80°, and 90° F., respectively. Although the roots of the plants were maintained at the four temperature levels, the tops of all the plants were subject to the same greenhouse temperature. These treatments were maintained over a 3-year period. The plants were subirrigated with nutrient solution, as frequently as needed to meet the moisture requirements. The intermittent air samples for the respiration measurements were collected by displacing the air with the nutrient solution. Half of the plants in each treatment were harvested in May 1949 and the remainder in April 1950.

At both harvests the root and top weights of the plants grown at 90° F. were about half that of the other treatments. The yields, at comparable harvests, of both tops and roots of the plants grown at 60°, 70° and 80° were nearly the same. The roots of all treatments contained a large mass of small fibers. This is in marked contrast with field-grown plants in which only 6 percent of the roots recovered are under 2 mm. in diameter. The total weight of roots per plant obtained in this experiment, excluding the 90° plants, exceeded that of field-grown plants. Although not significant the maximum yield

and the highest percentage of large roots were obtained at the 70°-level. No roots over 10 mm. in diameter were formed when the plants were grown at 60° or 90°.

The proportion by weight of leaves to stems and leaves and petioles to stems was not changed by the treatments. The yield of tops was reduced as the temperatures increased though not to the same degree as the root growth. This was shown by the top/root ratio which tended to increase with temperature.

There was a positive correlation betweeen the total chloroform extractives, rotenone equivalent, and rotenone with temperatures. No rotenone or rotenone equivalent was found in the fibrous (0–2 mm.) roots, irrespective of treatment or time of harvest. The "extractives" ranged from 1 to 2 percent, with the highest percentages occurring at the highest temperatures.

The starch content in the 2- to 10-mm. roots was essentially the same at 60° and 70° F. There was a marked reduction in the starch when the root temperatures were increased to the 80°- and 90°-levels. Although starch content decreased as temperature increased, there was a tendency for the hemicellulose content to remain constant.

The effects of temperature on the starch content of the fibrous roots were similar though not as pronounced as in the case of the large roots. An inverse correlation was found between the temperatures at which the roots were grown and their starch content. There was no consistent change in the hemicellulose content of the fine roots. There was no consistent change in the reducing sugar or sucrose of either large or small roots with changes in temperatures. Temperature treatments did not affect reducing sugar, sucrose starch, or hemicelluloses in the top parts of the plant.

Between 60° and 80° F. there was a nearly linear relationship between respiration and temperature. The temperature coefficient in this range was 1.4. A statistically significant inverse correlation was found between rate of respiration and the starch content of the entire root system. This relationship was the same whether measured by CO_2 evolution or O_2 consumption.

The data obtained in general showed that there was a decrease in insecticidal constituents with decreasing temperatures, although only the roots were subject to temperature differences and the tops were apparently normal. This is in agreement with the idea that the roots are the principal organ of rotenone synthesis.

In conducting the foregoing experiment a series of fundamental studies on root respiration were made. The objectives of these studies were: (1) To determine if there were diurnal fluctuations in the root respiration rates as measured by CO_2 evolution and O_2 consumption and (2) to establish the degree of correlation between respiration and solution absorption by the roots.

The data obtained showed that on any given day the respiration rate between 6 a. m. and 12 m. and from 12 m. to 6 p. m. was consistently higher than that of the two intervals of sampling made during the night. The diurnal fluctuation of root respiration occurred in all the plants, irrespective of temperature. The cyclic root respiratory activity was essentially the same whether measured by CO_2 production or O_2 consumption.

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Highly significant differences were obtained between sampling intervals for both CO_2 production and O_2 consumption. Both intervals gave the same order of rank. The criteria from the sampling periods 12 m. and 6 p. m. were approximately the same and both were greater by highly significant odds than the 6 a. m. period. The results at the 12 m. and 6 p. m. periods were significantly greater than those for the 12 p. m. and 6 a. m. periods, respectively.

The respiratory quotient was nearer unity during the daylight period when photosynthetic activity was greatest.

The data also showed that there was a relationship between the rates at which the solution was absorbed and the respiration of the roots.

A sampling apparatus was devised for installation in the gas stream line used in the respiration studies. This apparatus draws an aliquot of the air stream continuously into a container. The air samples thus collected can be analyzed for O_2 and CO_2 content and from these values it is possible to calculate the respiratory quotient.

Chemical Studies. M. P. Morris.

Seven species of plants which showed moderate to high toxicities in laboratory screening test for insecticidal properties were selected for chemical investigation: *Mammea americana* L., *Aeschynomene sensitiva* Sw., *Piscidia acuminata* (Blake) I. M. Johnst., *Leonotis nepetaefolia* (L.) R. Br., *Albizzia lebbeck* (L.) Benth., *Albizzia stipulata* (Roxb.) Boiv., and *Jacquinia aristata* Jacq.

The methods conventionally used for the isolation of the rotenoids and the pyrethrins could not be suitably adapted to the isolation of mameyin, the toxic component of mamey.

It was found that when a petroleum ether solution of the extract was placed on an absorption column prepared from alumina-celite and developed with petroleum ether, the components moved down the column at rates which were sufficiently different to permit their separation. With the use of chromotography and the conventional methods of crystallization, mamey extract has been separated into 11 fractions. Nine fractions were completely inert, and two were highly toxic. The toxicities of the latter appeared to be of the same order of magnitude as that of rotenone.

Extracts of fresh, mature, powdered fruit of mamey (*Mammea americana* L.) and of the powdered fruit which had been stored in steel drums for 6 years, showed no significant difference in toxicity. It is apparent from this test that the toxic principles of mamey are not lost in storage and are extremely stable in nature.

An extract of mamey, after being treated for the removal of fats and waxes, was subjected to temperatures up to 200° C. in a laboratory-constructed Hickman-type still. The still was sealed directly to a Cenco-Megavac pump. Only traces of inert fats were volatilized from the sample. The toxicity of the extract was not appreciably affected by this treatment.

Previous work by other investigators suggested that the toxic principle of mamey was a pyrethrin-like compound. It is apparent from the nonvolatibility of the active principle in the experiment on the toxicity of mamey that the toxic compounds of mamey are not pyrethrins.

Chloroform, acetone, ether, petroleum ether, alcohol, and acid extracts of the various parts of *Aeschynomene sensitiva* Sw. and *Albizzia lebbeck* (L.) Benth. were nontoxic or only slightly toxic to guppies. Calculated rotenone equivalents, based on the amounts required to kill 50 percent of the test animals in 6 hours, were less than 0.1 percent.

DRUG-CROP INVESTIGATIONS

Fertilizer Studies. H. F. Winters and A. J. Loustalot.

A field planting was made at the Toro Negro experimental plots in November 1947, of cinchona transplants taken from a nursery experiment where the plants were grown with four levels of light and three levels of nitrogen. After the nursery phase of the experiment had been completed the seedlings were pruned and transplanted to the field, where the experiment was continued with low, medium, and high levels of nitrogen application in factorial arrangement with the low, medium, and high levels maintained in the nursery. After the seedlings had been 1 year in the field a count showed that there was no difference in survival between treatments. There was an over-all survival of 80 percent. The principal cause of death was a root-rot disease thought to be caused by a species of *Phytophthora*. Although survival was good, growth was slow during the first year.

After the plants had been 2 years in the field survival dropped from 80 percent to 45.9 percent. Differences in survival between treatments were not statistically significant, although there was a trend toward higher survival with lower levels of nitrogen, both in the nursery and after transplanting to the field.

Field Studies. H. F. Winters.

A survey of cinchona plantings at Toro Negro reported previously [3] showed considerable variation between strains and species in survival and growth. The death of plants was attributed to a root-rot disease, presumably caused by a species of *Phytophthora* and to some extent to wind damage. Five strains with small populations were lost entirely.

The count made 18 months after the previous survey showed the same general survival trends. All strains showed additional reduction in stand. Greatest decrease in stand was usually found in *Cinchona ledgeriana* and *C. officinalis*. Best survival was usually found in strains of *C. pubescens* (*C. succirubra*) and hybrids in which this species seemed to be dominant. One exception was the strain of *C. ledgeriana* taken from tree No. 24 and a few similar trees at Maricao. Survival in this strain (42.9 percent) was the highest of the *C. ledgeriana* strains. These trees are also the most vigorous of their type.

During the past season flowering was observed in many different strains and some viable seed was produced. Flowering at the age of these plants is undesirable and is usually thought to indicate unfavorable soil or environment.

FOOD-CROP INVESTIGATIONS

Mangosteen Light Studies. E. P. Hume and H. F. Winters.

One of the difficulties encountered in establishing seedling mangosteens in the nursery or field is that of providing optimum light con-

[3] Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1949 : 7.

ditions. Previous trials at this station have shown that when light intensities are too low very little growth results, and when exposed to direct sunlight the young plants become chlorotic, growth stops, and the plants eventually die. An experiment was initiated to determine the optimum light intensity for young seedlings being transplanted from flats of peat in the greenhouse to outdoor nursery beds.

Three experimental light conditions were established—40 percent, 60 percent, and 80 percent of full sunlight—with four replications in randomized block arrangement. Very little growth took place for a year after planting. At 6 and 12 months height measurements revealed no significant differences between treatments. Height measurements at 18 months showed that the stronger light intensities produced a definite detrimental effect on the growth of the plants.

At the end of the experiment when the plants had been under treatment for 2 years there were definite differences in the results from different treatments. Plants grown under 40-percent light were of a better green color than those with a stronger light. Plants grown with 60-percent light, although slightly inferior to plants under 40-percent light, were much better in appearance than those under 80-percent light. Under the 40-percent-light treatment, the average height of plants was 49.8 cm. This height measurement was significantly larger than that attained under the 80-percent-light treatment, which averaged 30 cm. The effect of the 60-percent treatment was intermediate, producing plants with an average height of 40.1 cm. Stem diameter was significantly better under the 40-percent-light treatment than under the 80-percent-light treatment.

This experiment demonstrates the need for shade in mangosteen nurseries and suggests that the optimum results are obtained with 40 percent of full sunlight after the plants are established.

Mango Propagation. N. Alemyda.

An experiment was undertaken to find a method for establishing mango marcots on their own roots, after removal from the tree. Six treatments, arranged in a randomized split-plot design with four replications per treatment, were employed. Three pruning treatments were tried as follows: (1) Pruned to 1 foot, (2) complete defoliation, and (3) partial defoliation (removal of one-half of foliage from branch when severed from tree by cutting off terminal half of each leaf). Two root-ball treatments consisted of (1) completely removing the wrapping material, and (2) planting the plants with pliofilm intact but with four vertical 1-inch slits cut in the sides. About 25 percent of the air layers were established on the roots of the plant and no statistically significant differences were found in the establishment of the plants under different treatments.

Sweetpotato Breeding. H. E. Warmke and E. Cabanillas.

Three hundred and forty-two sweetpotato seeds were obtained from crosses made during the 1950–51 flowering season. These are largely from F_1 hybrids (Jersey×Moist Flesh) crossed back to fusarium-resistant and new moist-flesh types. The 342 seeds were obtained from a total of 1,884 crosses and represent an over-all seed set of 18.2 percent.

In these new hybrids it is hoped that the desirable characters of Orange Little Stem and the table-type moist-flesh varieties can be combined with the known fusarium resistance of the P. I. 153655 stock.

Of the seven Jersey varieties represented in the plots (all of which blossomed in 1949–50) only Orange Little Stem flowered during the 1950–51 season, and the fertility of this variety was low. From a total of 580 crosses with Orange Little Stem as a pollen parent, only 7 seeds were obtained for a set of 1.2 percent. This compares very unfavorably with a set of 63 seeds obtained from 1,086 crosses made with this variety in 1949–50. It is believed that the poor showing of the Jersey varieties this year is attributable to a severe infestation of the sweetpotato weevil (*Cylas formicarius elegantulus* (Sum.)) to which these varieties are especially susceptible.

Crossing was started early in November and extended to the last of December, when nearly all plants showed signs of infestation and ceased to produce flowers. The old plantings have been completely destroyed and new and isolated plots are now being established for next year's crossing.

Sweetpotato Flowering. E. Cabanillas and H. E. Warmke.

Thirteen F_1 hybrids from crosses between Jersey and moist-flesh varieties of sweetpotatoes have flowered at Mayaguez during the past year. These include B–6146, B–6148, B–6149, B–6152, B–6153, B–6157, B–6159, B–6160, B–6161, B–6166, B–6167, and B–6168. The following hybrids have not yet produced blossoms: B–6143, B–6145, B–6162, B–6164, and B–6165. In addition, five new moist-flesh introductions, Oklahoma 24, B–6026, B–6114, B–6122, and L–241 have come into flower and are being used in the breeding program.

Sweet Corn Breeding. H. J. Cruzado.

Two hundred and forty-five different sweet corn lines, including 40 hybrids, 197 S_2 inbreds, and 8 field open-pollinated lines were grown during October, November, and December. All lines were derived from selfings and crosses made at Mayaguez during the previous winter.

USDA–34 S_2 inbreds lost vigor in comparison with the S_1 inbreds. Small, thin plants with small, grainless ears were common. Sterile tassels, with pollen sacks that never opened, complicated the breeding problem in many inbreds. Segregants that appeared in the former planting were nearly eliminated in this planting.

Hybrids between different S_2 lines derived from the same original USDA–34 stock, and some hybrids between USDA–34 and various continental inbreds, exhibited hybrid vigor—in increased height and thickness of stalks, in greater yield, in earliness of maturity, and in better quality—over noninbred USDA–34 corn. Seeds of the better hybrid lines will be planted for seed distribution to farmers.

As before, Connecticut lines were earlier in production than USDA–34 and the resulting hybrids with USDA–34 inbreds also inherit this characteristic. Quality and yield of most of these lines were extremely poor. Only hybrids 50324 (USDA–34 × Jones C. 23), 50325 (USDA–34 × Jones USDA–34), and 50326 (USDA–34 × Jones C. 23) show promise.

All Connecticut FOP plants and USDA–34 Line No. 50138 showed great susceptibility to 2,4–D when this herbicide was used to control weeds. Damage by the corn earworm (*Heliothis armigera* (Hbn.)) and the fall armyworm (*Laphygma frugiperda* (A. & S.)) was negligible in all lines.

PLANT INTRODUCTION AND PROPAGATION

Plant Introduction. H. F. Winters and N. Almeyda.

A total of 190 introductions were received from 12 foreign countries and from the United States and Territories. Introductions of particular interest were 15 species and varieties of *Strophanthus*, several pounds of seed of *Macadamia ternifolia*, 2 strains of black pepper, *Piper nigrum* L., 9 species of *Ficus*, 1 plant of *Melocanna baccifera*, and 12 hybrid tropical waterlilies.

The *Strophanthus* plants were grown by the Bureau of Plant Industry, Soils, and Agricultural Engineering at Glenn Dale, Md., from seed collected by an expedition which the Division of Plant Exploration and Introduction sent to Africa after the discovery that seed of some species of *Strophanthus* contains a substance which can be converted into the drug cortisone.

Melocanna baccifera is the fruiting bamboo of India and Burma which bears large, fleshy, pear-shaped fruits 3 to 5 inches long and 2 to 3 inches broad. The culms are useful for building and weaving.

A number of promising forage crops, both legume and grasses, were also received.

Distributions. H. F. Winters and N. Almeyda.

The local demand for plants has been great but the supply somewhat limited because of change in policy and reductions in the labor force. A total of 4,579 ornamental plants and trees were distributed during the year to government agencies and individuals.

A total of 525 packets of seed representing 338 species were sent to 18 foreign countries and to various parts of the continental United States. Cuttings of *Piper nigrum* were sent to Honduras and seed to Mexico; cuttings of citronella grass, *Cymbopogon nardus*, to Ethiopia and to Guatemala; and seed of *Canangium odoratum* to Brazil and to Dominica, B. W. I.

A total of 71 requests for tropical kudzu seed, amounting to 148 pounds, were received during the past year from 8 countries. Puerto Rico was first in number of requests, with 58, and 125 pounds of seed were distributed locally. Other countries to which seed was distributed were Cuba, the Bahama Islands, India, French West Africa, Mexico, Southern Rhodesia, and the United States.

Kenaf Experiments. N. Almeyda.

Experiments were conducted to determine (1) the optimum planting distance, (2) the optimum number of seeds per hole, and (3) the limits of vegetative and reproductive seasons for seed production of Kenaf (*Hibiscus cannabinus* L.).

The spacing trial consisted of three treatments replicated eight times. The distances between plants were 2, 4, and 8 inches and rows were spaced 21 inches apart.

The same design was used to determine the optimum number of seed per hole, but only one spacing was used, 4 inches between holes and 21 inches between rows, replicated three times. Plots were seeded at the rate of 2, 4, and 6 seeds per hole.

To determine the effect of season on vegetative and reproductive growth, plantings of three 16-foot-row plots were made every 15 days, starting August 1, 1949, and ending October 15, 1949.

The highest yield of seed was obtained when the seed were planted 2 inches between plants in rows 21 inches apart. A uniform stand of plants was not obtained with 2 seeds per hole because of poor germination. When 6 seeds per hole were planted many plants were lost in thinning and a larger amount of seed was needed per acre. The optimum planting was 4 seeds per hole.

The best time of planting for seed production was during the month of August. Planting in this month allows for approximately 2 months of vegetative development before flowering starts and seed production tends to increase. As plantings are made later in the season, the plants tend to be smaller and seed yield decreases.

MANGROVE VIVIPARY. C. D. La Rue and T. J. Muzik.

An attempt was made to determine whether the viviparous embryos of the black mangrove, *Rhizophora mangle* L., will form roots before they are fully mature and fall off. Embryos not more than one-third full size will root prematurely if planted in sand. Those planted in sand and irrigated with fresh water developed 20 times as many roots as the same number irrigated with salt water.

It has been found that the mangrove is rather efficient in planting its embryos in the mud. A relatively small number (4 percent ±) fail to fall perpendicularly and stick in the mud and although these may bend their stems and come to grow erect, their chances of survival are less than those stuck upright.

SAUSAGE TREE MERISTEM. T. J. Muzik and H. J. Cruzado.

Kigelia pinnata DC., the sausage tree, is so named because it bears sausage-shaped fruits on long, pendant peduncles. Investigations have been made to determine the longevity and habit of growth of this interesting plant. As far as is known, it is the only tree producing a perennial flower stalk of this kind, with its own terminal meristem and cambium, that produces wood over a number of years.

The flower stalk may be as much as 370.0 cm. long and 2 cm. in diameter at the base. A peduncle of this length is probably 2 to 3 years old. Considerable wood is produced by the cambium. The peduncle has typical stem structure internally, although it superficially resembles an aerial root. Elongation occurs primarily in the lowest 2 mm., in which respect it also resembles a root.

The terminal meristem is unique in that it differentiates only in floral tissue, that is, no leaves or buds are produced along the axis. The flower stalk does not appear to differentiate from a special bud. Terminal or axillary buds on any branch may differentiate into a flower stem. A cushion of tissue is produced at the base of the peduncle which goes on producing new floral shoots indefinitely. When a peduncle meristem is removed or injured, the entire peduncle dies back from the tip and no axillary buds are formed. One shoot is usually

produced at a time and seldom more than two at once. This appears to be a clear-cut inhibition of one flower by another flower.

Cuttings have been made, using peduncles of various sizes treated with indoleacetic, indolebutyric, or naphthaleneacetic acid at concentrations of 100 and 200 parts per million in cocopeat and at 1, 10, and 100 parts per million in nutrient solutions. Large amounts of callus were formed but no roots differentiated. Marcots were made by girdling the stem below the node and wrapping the cuttings in sphagnum after they had been given hormone treatment. The stem was able to form callus over a girdle 3 cm. long, but no roots have been formed.

Sections of stem and terminal meristems were sterilized and placed in a complete nutrient culture on an agar medium. Although many of these stem pieces lived for 6 to 8 months and produced a large callus, no roots were ever differentiated. This callus is produced mostly by the cambium and young phloem.

Forty percent of the branch cuttings from the sausage tree have rooted, showing that a distinct difference between the branch and the peduncle exists in this respect.

PERENNIAL LEAF STUDIES. T. J. Muzik.

Skutch [4] has described briefly the perennial leaves of *Guarea rhopolocarpa* Radlk. found in Costa Rica. A related species, *Guarea trichilioides* L., is endemic in Puerto Rico. Both of these plants produce leaves which persist and grow for many years. The leaves are pinnately compound with from 5 to 7 pairs of leaflets, each leaflet being about 10 inches long and 2 to 3 inches broad. The end of the rachis is terminated by a bud which consists of several pairs of leaflets, folded together upward, with their margins rolled upward, and a terminal growing point. The bud is covered with short hairs, but there are no bud scales. These buds periodically give rise to new lengths of rachis, bearing additional pairs of leaflets, usually 2 to 3 pairs for each leaf. The longest leaf measured in Puerto Rico was 80.0 cm. in length and was probably 5 to 8 years old.

There is an active cambium, and much secondary wood is produced. As far as is known, this is the only genus of higher plants which produces perennial leaves. The genus is strictly tropical.

Attempts have been made to root cuttings of these leaves under various conditions. Success has finally been achieved by placing the cuttings in cocopeat under a continuous spray in full sunlight and treating with 0.02 percent indolebutyric acid. Ten percent of the cuttings so treated rooted after 3½ months. Similar treatments inside the green house failed completely, indicating that full sunlight as well as moisture and hormones are needed to form roots in this leaf. Good success has also been obtained with marcots after treatment with indolebutyric or naphthaleneactic acid.

It will be of considerable interest to see if this leaf has the ability to continue indefinite growth when thus separated from the tree. Rooting of leaves of other plants previously has been reported, but in these cases the leaf either has no capacity for further growth or re-

[4] SKUTCH, A. F. COMPOUND LEAF WITH UNUSUAL INCREMENTS OF GROWTH. Torrey Bot. Club Bul. 73: 542–546. 1946.

generates a new stem bud usually from callus tissue. No other example has been previously reported of a plant like *Guarea*, in which the leaf has its own meristem as well as its own roots.

PHOTOPERIOD EXPERIMENTS. T. J. Muzik and H. J. Cruzado.

Experiments were conducted to determine the effect of light and hormones on floral and vegetative differentiation of plants. Members of the Bromeliaceae, such as the red Spanish pineapple, were found to be particularly suitable for these studies. Treatments to delay flowering were made at two different times, in early December, before visible differentiation, and in January, when differentiation had begun; the red coloration of the inner leaves was used as a criterion. Maleic hydrazide as the diethanolamine salt was dissolved in water and poured into the center of the pineapple plant. Concentrations of 1.0, 0.1, 0.01 percent were applied at the rate of 10 cc. or 20 cc. to each plant. The first application was made on December 6. Flowering began in late December on the controls and records were taken on December 26, January 10, and March 24. Length of fruits was measured on April 2.

The most effective treatment was 20 cc. of 1.0 percent solution per plant. The fruits in these plants are slightly more than one-half the size of those in the control group, and appeared to be normal in appearance. They were first visible about 2 months later than the control fruits.

The second experiment was carried out on January 11, 1951. Since no apparent injury was done to the plants previously treated, it was decided to use larger amounts of the chemical. Most of these plants had already begun to flower. Accordingly, 0, 20, 40, 60, 80, or 100 cc. of 1.0 percent of maleic hydrazide was applied to 20 plants in each treatment. These plants flowered and fruited at the same time as the controls but the growth of the crown has been completely suppressed on all treatments, although the fruits themselves are about the same size as the controls. The individual fruitlets are more separate than in the untreated plants and the bracts below the fruitlets seem to be slightly longer.

Treatment of the plants which had already initiated flowering indicate that the maleic hydrazide affected differentiation more than it did the elongation; for once past the critical point, flowering was not delayed even at the high concentrations used, although some distortion was visible in these fruits.

ENTOMOLOGY

ESTABLISHMENT OF INTRODUCED BENEFICIAL INSECTS. H. K. Plank.

Collections of sugarcane borers (*Diatraea saccharalis* (F.)) were made in sugarcane "dead hearts" and corn in 10 municipalities over the island. The purpose of these collections was to study in the spring of the year the establishment of the 12 species of larval parasites of the borer that had been introduced and liberated since 1935 in these municipalities and in 6 others not far away.

As was the case last year, the native tachinid, *Lixophaga diatraeae* (Towns.), was found to be well distributed over the island. Parasitism by this species ranged up to 34.6 percent and averaged 15.74 percent among all collections.

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Agathis stigmaterus (Cress.) was reared from two collections, one from corn at Añasco and the other from sugarcane dead hearts at Guayama. This species was originally introduced about 1928 and again in 1935, both times from British Guiana. Further introductions were made in 1939 and 1942, both of these from dry regions in the State of Sao Paulo, Brazil. Recoveries of this parasite were previously made at Hormigueros in 1936 and at Añasco in 1938, but the percentage of parasitization was never over 4.8, about twice the maximum parasitization found in the present collections. The recovery at Guayama is a new record. Since Guayama is in a dry area, this may represent establishment of the dry-land strain from Brazil, which was liberated at nearby Santa Isabel in 1939.

Six collections of green-bean pods and leaves infested with the pod borer (*Maruca testulalis* (Geyer)) and leaf tier (*Hedylepta indicata* (F.)) were made at Isabela and Barceloneta. The braconid parasites, *Macrocentrus ancylivorus* Roh. and *Phanerotoma planifrons* (Nees) had been introduced from New Jersey and liberated in these places in 1936 and 1938. No evidence of the establishment of these parasites was found, but several native species were reared from the present collections. Two species of flies, *Sarcophaga* sp. and *Argyrophylax albincisa* (Wd.), parasitized 0.3 percent of the *Maruca* larvae collected and 12.8 percent of the *Hedylepta*, respectively. A small wasp, *Apanteles* n. sp., parasitized 4.6 percent of *Maruca* and 27.7 of *Hedylepta*.

None of the several collections of one of the West Indian fruit flies, *Anastrepha suspensa* (Lw.) in guava fruits (*Psidium guajava* L.) made during the year yielded any parasites. This compares with a recovery of only two specimens of the native parasite *Trichopria* n. sp. from 625 larvae in 113 guava fruits collected at Juana Diaz during the previous September. Apparently *A. suspensa*, at least in guava fruits, is not very susceptible to parasitization, which confirms observations made on this species in 1936.

Parasites reared from the other West Indian fruit fly, *Anastrepha mombinpraeoptans* Sein. in hog plums (*Spondias mombin* L.) have been determined as the foregoing species and *Spalangia drosophilae* Ashm. The latter species, a native parasite, was previously reared from horn fly puparia (*Siphona irritans* (L.)) from Guanica, but this is the first record of its occurrence on *A. mombinpraeoptans*. The occurrence of this parasite on either of these hosts may be rare, since in both instances only one specimen was recovered.

The native parasite *Spalangia muscidarum* Rich., occurred in moderate numbers in collections of house fly puparia from Mayaguez and Hormigueros and of stable fly puparia from Salinas and Guayama. Another native parasite, a new species of *Trichopria*, was reared from stable fly puparia from Ponce. This small wasp has previously been recorded from fruitfly puparia.

Another species of *Spalangia*, *S. afra* Silv., was reared from collections of house fly puparia from Mayaguez, Hormigueros, and Cabo Rojo. This parasite is known to occur in Texas and North Carolina, as well as parts of Africa, Australia, and India, where it attacks a number of widely distributed species of flies. It was probably introduced here accidentally many years ago.

Spalangia philippinensis Full., brought in from Hawaii in 1937 to aid in the control of the horn fly, was not encountered in any of the collections of host material made during the year. Since there has been no record of its occurrence since its recovery shortly after liberation, it appears that this species was not able to maintain itself under local conditions.

An unidentified genus and species of a native staphylinid belonging to the parasitic subfamily Aleocharinae was reared from one collection of house fly puparia from Mayaguez. Parasitization was about 22 percent.

None of the four species of dung beetles that were introduced from Hawaii and Texas in 1936–38 to aid in the control of the horn fly, were recovered. Extensive search carried out during the past year in most of the eight municipalities on the east, south, and west coasts of the island where they were liberated failed to reveal any trace of these beneficial insects.

Adults were reared from the larvae of several species of flies found in the egg sacs of the pineapple mealybug (*Pseudococcus brevipes* (Ckll.)). The most abundant of these were two heretofore unrecorded itonidids (cecidomyiids), one an unidentified species apparently of the tribe Oligotrophiini, and the other *Dicrodiplosis coccidarum* Felt. The relatively common *Leucopis bella* Lw. was reared in small numbers from one collection from Palmarejo near Lajas. This species was also reared from larvae found in egg sacs of the Mexican mealybug (*Phenacoccus gossypii* Towns. & Ckll.) on *Acalypha wilkesiana* Muell. Arg. at Mayaguez.

Beneficial work of the hymenopterous parasite *Pseudaphycus utilis* Timb., introduced from Hawaii to aid in the control of the coconut mealybug (*Pseudococcus nipae* (Mask.)) was again noted. In addition to its recovery at Mayaguez, Lajas, and Juana Díaz, previously reported, it was found present in seven other municipalities, principally in the western end of the island. Evidence of its parasitization was seen in light to moderate mealybug infestations on avocado, coconut (*Cocos nucifera* L.), and guava. Direct spreads of up to about 40 kilometers from nearest points of liberation were observed.

An apparently new species of *Anagyrus* was reared in small numbers from a collection of the coconut mealybug on coconut leaves. This small amber-colored wasp is very similar to *A. ananatis* Gahan introduced from Hawaii and previously noted as recovered from the pineapple mealybug at Lajas.

A minute encyrtid wasp determined as *Cheiloneurus* sp. near *pulvinariae* Doz. emerged in the same cage with the foregoing *Anagyrus* n. sp. It also occurred in cages containing coconut mealybug material from which the introduced parasite *Pseudaphycus utilis* was recovered. *C. pulvinariae* has been recorded as a hyperparasite of another encyrtid, *Aphycus flavus* Howard, parasitic on *Pulvinaria iceryi* Guerin on sugarcane in Puerto Rico. It is possible, therefore, that the species of *Cheiloneurus* encountered here may have been hyperparasitic on both *Anagyrus* and *Pseudaphycus*, which were parasitizing the mealybugs.

The itonidid (cecidomyiid), *Lobodiplosis* sp., was reared in moderate numbers from a collection of the coconut mealybug on leaves of the arica palm (*Chrysalidocarpus lutescens* Wendl.) from Aguirre.

The small, black eulophid (aphelinid) wasp *Coccophagus heteropneusticus* Comp., introduced from Brazil, was reared in moderate numbers from a collection of coconut mealybugs and scale insects on guava leaves at Mayaguez.

Another species of the same genus, *Coccophagus lycimnia* (Walk.), probably native, was also reared in moderate numbers from collections of coconut mealybugs and soft scales on guava leaves and of the black scale (*Saissetia oleae* (Bern.)) on leaves of the West Indian almond (*Terminalia catappa* L.) from Lajas.

No parasites, introduced or native, could be reared from collections of the green scale from the coffee grove where the introduced *Coccophagus heteropneusticus* was originally liberated, no mealybugs and few other scale insects were present. Failure of recovery was probably due to the fact that the host requirements for male *Coccophagus* are peculiar. *C. heteropneusticus* and *C. lycimnia* will only succeed under conditions where mixed scale populations exist and where other parasites are present to serve as hosts for the male *Coccophagus*.

Two species of ladybeetles have become established by natural spread at various points where liberated colonies of *Egius platycephalus* Muls. had apparently failed. These species were *Chilocorus cacti* (L.) at Arecibo, Bayamón, and San Juan, and *Cladis nitidulus* (F.) at Bayamón, Dorado, Guaynabo, Río Piedras, and Gurabo. Both species had originally been liberated at Bayamón. The activity of *C. nitidulus* helped to control infestations of the green scale on gardenia and of *Orthezia praelonga* Doug. on bougainvillea at Mayaguez.

Curinus sp., a metallic blue-green ladybeetle was found feeding on *Asterolecanium miliaris* (Bav.) on bamboo and on green scale on gardenia at Mayaguez. This species is easily confused with the foregoing *Cladis nitidulus*, which is a little larger and has metallic purple-green elytra.

A few adults of a species of *Pentilia* having a large, obscure red dot in the center of each wing cover were recently found on the purple scale (*Lepidosaphes beckii* (Newm.)) and other scales on orange at Mayaguez. This is probably the first recovery of the red-dotted *Pentilia* since its introduction from Trinidad and British Guiana and its colonization on bamboo scales in 1937.

The ladybeetle, *Coelophora inaequalis* (Fabr.), introduced from Hawaii in 1938 and liberated in nine municipalities to aid in the control of the yellow sugarcane aphid (*Sipha flava* (Forbes)), was found attacking the cotton aphid (*Aphis gossypii* Glov.) on cotton bolls at Cabo Rojo. It was also seen feeding on the sugarcane aphid on the grass, *Digitaria sanguinalis* (L.) Scop., and *Macrosiphum luteum* (Buckt.) on *Cattleya trianae* at Mayaguez.

Three species of small native hymenopterous parasites were reared from the cotton aphid on trellised tropical kudzu at Mayaguez. The most abundant of these were encyctid *Aphidencyrtus* sp. and the eulophid (aphelinid) *Aphelinus* sp. A few specimens of a braconid, *Aphidius* (*Lysiphlebus*) n. sp., were also present.

Collections of the pink bollworm (*Pectinophora gossypiella* (Saund.)) were made in an area where three species of hymenopterous parasites introduced from Texas had been liberated in large numbers in 1935 and 1936. None of these collections yielded any speci-

mens of the introduced species, although all three parasites had previously been recovered within a few months after their release.

Collections of the cotton stainers, *Dysdercus* spp., mostly *D. andreae* L., on *Thespesia populnea* (L.) were made at places where the larvaevorid flies *Acaulona peruviana* Towns. and *Hyaloma chilensis* Macq., introduced from Perú, had been released in 1941 and 1942. Neither of these species was recovered from this material.

However, the native species reported last year as *Acaulona* n. sp. was again encountered. This parasite has now been described as *Acaulona erythropyga* Sabrosky.

The histerid beetle, *Plaesius javanus* Erichson, was introduced from Fiji in 1936 to aid in the control of the banana root weevil (*Cosmopolites sordidus* (Germ.)), and releases were made in heavily infested banana and plantain fields in Mayaguez and Juana Díaz. Many examinations made of host food plants during the past 18 months at these points and elsewhere failed to show any evidence of the presence of this much-needed predator.

The native predaceous mite, *Iphidulus tiliae* (Oudms.) occurred in small numbers with the phytophagous mite, *Tetranychus planki* McG., on the under side of the leaves of tropical kudzu (*Pueraria phaseoloides* (Roxb.) Benth.).

The small, native black fly, *Carpolonchaea* sp. (pendula group, possibly n. sp.), was reared from guava fruits from Mayaguez. These fruits were infested with larvae of an apparently new species of *Gymandrosoma*, family Olethreutidae. Since no flies were reared from uninfested fruit collected at the same time and place, it is probable that they were predaceous on the moth larvae here recorded.

SOIL-EROSION CONTROL AND STABLE CROP PRODUCTION IN PUERTO RICO

LEGUME EVALUATION. R. H. Freyre and H. E. Warmke.

An experiment was carried out over a 3-year period to compare five superior legumes with respect to nitrogen fixation and forage yield on two soil types, a fertile lowland soil and a heavy clay upland soil.

On the fertile soil, the grass-legume combinations produced more forage than either the grass or legume grown alone. The plots containing the combination Merker grass-trailing indigo produced a total of 73,575 pounds of dry matter during the course of the experiment, to lead all others. Trailing indigo thrived in combination with Merker grass and recovered rapidly after cutting. The use of this combination cannot be recommended at present, however, because of the possible toxicity of trailing indigo to livestock.

The Merker grass-tropical kudzu combination was a close second in total yield, with an average production of 67,469 pounds of dry matter per acre. This is also a compatible combination, with both grass and legumes growing well together. The other combinations, Merker grass-cowpea, Merker grass-red bean, and Merker grass-velvetbean, can be considered essentially incompatible.

On the upland soil, tropical kudzu and trailing indigo were the only legumes to establish themselves in combination with the grass, and these were slow and made poor growth. Under these conditions

the Merker grass plots were first in yield, followed by the combinations, Merker grass-tropical kudzu, Merker grass-velvetbean, Merker grass-trailing indigo, and Merker grass-red bean. The reduced yields of the grass-legume combinations in this field (even when the legume in the combination grew too poorly to be harvested) remain largely unexplained. Two observational plots of Merker grass fertilized yearly with 700 pounds of ammonium sulfate per acre outyielded all other combined or single species, with a total of 73,653 pounds of dry matter.

Combinations of Merker grass and trailing indigo and Merker grass and tropical kudzu are apparently productive on fertile soils. Under poorer soils grass-legume combinations do not appear to be advantageous, unless better methods can be devised for stimulating the establishment and growth of the legumes.

KUDZU FLOWERING. H. E. Warmke.

An effort was made to bring tropical kudzu into flower earlier in the season, so that fresh pollen of kudzu grown in the States (which flowers during the summer months on the continent) might be used in crossing attempts. Since tropical kudzu flowers in the fall in Puerto Rico, on a shortening photoperiod and a cooler temperature, it was decided to include these two factors in the tests.

On August 14, approximately 3 months before field-grown plants are expected to flower, six plants were divided into groups of two each and given the following treatments: Group 1, placed in a dark room at air temperature at 4 p. m. each day and in sunlight at 8 o'clock the next morning (8 hours' light); group 2, placed in a dark room at 15° C. at 4 p. m. and in light again at 8 o'clock the next morning (8 hours' light); and group 3 (control) kept outside at all times (12 to 12½ hours' light at this station). The treatments were continued for 6 weeks, after which time all plants were kept out of doors under conditions of normal temperature and photoperiod.

None of the treatments was successful in inducing early flowering.

LEGUME PALATABILITY AND TOXICITY. H. E. Warmke and R. H. Freyre.

Preliminary trials have been conducted with some of the more promising legume species to determine their palatability and possible toxicity to guinea pigs. This is an initial step in the evaluation of these legumes as forage for cattle. Preliminary results are now available on the following six species: *Calopogonium coeruleum* Benth., *Centrosema pubescens* Benth., *Dolichos lablab* L., *Indigofera endecaphylla* Jacq., *I. subulata* Vahl, and *Pueraria phaseoloides* (Roxb.) Benth.

All animals fed on *Indigofera endecaphylla*, *I. subulata*, and *Calopogonium coeruleum*, either died or came close to death before being changed to other rations. On trailing indigo (*I. endecaphylla*), animals lost weight and died in an average of 14 days. In the case of *I. subulata* animals lost weight and all died. It was observed that only a small amount of these two legumes was eaten by the animals and then only when fresh. Five animals were tested on *C. coeruleum;* four of these died. These animals lost an average of 210 gm. and lived an average of 20 days after the start of feeding. The fifth when on the verge of death was put back on the grass-grain combination and recovered.

Three of the legumes tested (*Centrosema pubescens*, *Dolichos lablab*, and *Pueraria phaseoloides*) did not show any deterimental effects on the guinea pigs.

Since the amounts of the legumes consumed were not weighed in these trials, it was not possible to determine whether the four animals fed on the two *Indigofera* species and the *Calopogonium* died because they failed to eat the forage provided, and thus died of starvation, or if they ate the legumes in small quantities and died because of some toxic substance present in them.

In order to distinguish between these two alternatives, a new series of tests was run. In these tests 9 animals were started on a diet of 1 part of fresh tropical kudzu leaves ground (with some water) in a Waring blendor and then mixed with 3 parts of commercial cattle concentrate to form a wet mash. The amount of food served each day was weighed accurately and the amount remaining the next morning was also weighed. The difference (plus a factor for evaporation) represented the amount of mixture consumed, and from this the amount of actual legume consumed was calculated.

Although the kudzu-concentrate mash was a safe and nutritive food, 3 animals accustomed to a grass diet failed to eat it and died, presumably from starvation. Two others were returned to their original diet after it was obvious they would not eat the new rations. The other animals made the change in diet successfully and maintained their original weight or gained.

The animals that adjusted themselves to the new diet were divided into 4 groups: Three groups were fed rations in which the two indigos and the *Calopogonium* were ground in the blendor and substituted for the kudzu in the combination, and the fourth or control group was maintained on the kudzu mixture. The animals receiving the kudzu and the two indigoferas continued to eat their feed and maintained their weights. The one receiving the *Calopogonium* ate practically nothing and was retired from the diet after 6 days, because it was on the verge of death.

Two weeks later, the feed was changed to 1 part of ground legume leaves to 1 part of concentrate, and another animal was added for each treatment. The single animal receiving the *Calopogonium* ate very little (less than 3 gm. of legume per day) and died after 7 days. Those on the two indigofera species continued to eat the mixtures, and consumed, on the average, between 21 and 27 gm. of fresh legume daily, for a period of 4 months. These animals have shown no ill effects and have maintained about the same weights as those fed on the kudzu mixture.

The results obtained indicate that (1) mature guinea pigs do not make changes in diet readily—that they may starve to death with a palatable food before them, if they are not accustomed to that food; (2) that they may take substantial amounts of *Indigofera endecaphylla* and *I. subulata*, once they have learned to eat these legumes, without apparent ill effects; (3) that the deaths observed after feeding the indigoferas unground were probably a result of failure to eat the legumes; and (4) that guinea pigs will eat so little *Calopogonium coeruleum* that they probably die of starvation.

The fact that guinea pigs may be induced to consume substantial amounts of the two indigoferas in the form of a wet mash in combina-

tion with concentrate, is of interest, especially in the light of recent reports of toxicity of *I. endecaphylla.*

LEGUME CAFETERIA TRIALS. H. E. Warmke and R. H. Freyre.

During the course of the year, an animal cafeteria was set up to determine the relative palatability of a group of 10 different legumes. These were selected from introduction trials on the basis of their ability to grow vigorously, and little was known of their properties as forage crops. The species included in the test were: *Calopogonium coeruleum* Benth., *Canavalia bonariensis* Lindley (red bean), *Centrosema pubescens* Benth., *Desmodium intortum* (Mill.) Urb., *D. nicaraguense* Oerst., *Dolichos lablab* L., *Indigofera endecaphylla* Jacq., *I. subulata* Vahl, a hairy tropical kudzu and a mutant hairless tropical kudzu, both *Pueraria phaseoloides* (Roxb.) Benth.

Relative palatability was measured in two ways: (1) By determining the amount of each legume consumed by dairy cattle, and (2) by observing choice and duration of grazing on each species.

Indigofera endecaphylla, *Canavalia bonariensis*, and *I. subulata*, in that order, led in the amount of total forage produced, and in amounts of green matter consumed by the cattle.

During the first six grazing periods the cattle spent more time on the plots of *I. endecaphylla* than on all the other plots combined. The *Calopogonium* and *Pueraria* species did not at any time attract the cows for long periods, and accurate determinations were somewhat difficult with these species because of the presence of weeds. Cattle did not touch *Dolichos lablab* during the early grazing periods, but consumption reached a peak during the seventh grazing period when the animals spent nearly one-half of their time on these plots. This is interpreted to mean that when the choice forage had been consumed from the plots of the preceding species, then and not until then, did the animals consume *D. lablab.*

In like manner the longest period of grazing for the remaining species was nearer and nearer the end of the experiment. *Canavalia bonariensis*, which is probably the least preferred of all the species tested, was not consumed in appreciable quantities until the fourth day from the end of the experiment—after most of the palatable forage had been removed from the plots of the preceding species.

These results, although they include only the first round of cafeteria grazing, place *Indigofera endecaphylla* in a very favorable light. This species ranked first in production and in all criteria of palatability. The two varieties of kudzu, on the other hand, ranked fourth and seventh in production, fourth and seventh in the amount consumed, fifth and sixth in percentage consumed, seventh and eighth in total grazing time, and third and fourth in order of preference, among the 10 species tested.

FORAGE PATHOLOGY. T. Theis.

During the past year, the various forage areas of the island have been surveyed to determine the prevalence of disease on the respective forage crops. Specimens have been collected and preserved. Identifications of the pathogenic organisms have been made by the Division of Mycology and Disease Survey, BPISAE. Photomicrographs of the spore types as well as close-up photographs of the disease

lesions have been made. Diseases of minor importance because of their infrequency have not been included.

The following Puerto Rican forage grasses have been observed to be infected with the following diseases:

Axonopus compressus (Swartz) Beauv. (Tropical carpet grass). Leaf spot caused by *Trichostroma Axonopi* Tehon.

Cynodon dactylon (L.) Pers. (Bermuda grass). Rust, caused by *Puccinia cynodontis* Lacroix. Helminthosporium spot, caused by *Helminthosporium cynodontis* Marignoni.

Eriocloa polystacha H. B. K. (Malojilla). Rust, caused by *Uromyces lepotodermus* Syd.

Melinis minutiflora Beauv. (Molasses grass). Ergot, caused by a species of *Claviceps.*

Panicum maximum Jacq. var. guinea (Guinea grass). Ergot, caused by a new species of *Claviceps* not previously reported. Black streak, caused by *Phyllosticta panici* E. Young. Stem streak, caused by a new species of *Apiospora* not previously reported. Cercospora spot, caused by *Cercospora fusimaculans* Atkin.

Panicum maximum Jacq. var. gramalote (Gramalote). Ergot, caused by a new species of *Claviceps.* Black streak, caused by *Phyllosticta panici* E. Young. Cercospora spot, caused by *Cercospora fusimaculans* Atkin.

Panicum purpurascens Raddi (Malojillo). Ergot, caused by a species of *Claviceps.* Rust, caused by *Uromyces leptodermus* Syd.

Paspalum conjugatum Bergius (Cintillo). Ergot, caused by a species of *Claviceps.*

Paspalum plicatulum Michx. (Gamelotillo). Ergot, caused by *Claviceps paspali* Stev. et Hall. Eyespot, caused by a new species of *Phyllosticta.* Rust, caused by *Puccinia dolosa* Arth. & Fromme.

Paspalum virgatum L. (Cortadero). Ergot, caused by a species of *Claviceps.* Tar spot, caused by *Phyllachora graminis* (Fr.) Fokl.

Pennisetum purpureum Schumach. (Napier grass). Eyespot, caused by *Piricularia grisea* (Cke) Sacc.

Pennisetum purpureum var. *merkerii* (Merker). Eyespot, caused by *Piricularia grisea* (Cke) Sacc.

Sorghum vulgare Pers. (Sorghum). Rust, caused by *Puccinia purpurea* Cooke.

Sporobolus indicus (L.) R. Br. (Dropseed). Sooty spike, caused by *Helminthosporium ravenelii* Curt. Rust, caused by *Uromyces ignobilis* (Syd.) Arth.

Sporobolus poieretii (Roem. & Schult.) Hitchc. (Smutgrass). Sooty spike, caused by *Helminthosporium ravenelii* Curt. Rust, caused by *Uromyces ignobilis* (Syd.) Arth.

Stenotaphrum secundatum (Walt.) Kuntze (St. Augustine). Smut, caused by *Ustilago affinis* Ell. & Ev.

Tripsacum laxum Nash, N. (Guatemala). Rust, caused by *Puccinia polysora* Underw.

The following legumes have been observed to be infected with the following diseases:

Pueraria phaseoloides (Roxb.) Benth. (Tropical kudzu). Powdery mildew, caused by a species of *Oidium.*

Stizolobium Deeringianum Bort (Velvetbean). Cercospora spot, caused by *Cercospora stizolobii* Syd.

Ergot on Guinea Grass. T. Theis.

In the last annual report, the high incidence of ergot on guinea grass in the southwestern dairy region of Puerto Rico was reported. During the last flowering season (1950) a similar severe infection occurred, indicating that this may occur every year. As in the first observation, the number of sclerotia was high. Since this disease in other grasses is known to be toxic to animals, the need for feeding trials was evident.

A number of tests were initiated using guinea pigs as test animals and Para grass as the staple food. Hand feeding of ergot was employed to insure that known amounts of the fungus were ingested. Toxicity symptoms looked for were nervousness, erratic movements, convulsions, atrophy of terminal appendages, bleeding or abortion of pregnant females, or death.

In addition to actual feeding trials with test animals, the alkaloids (toxic components) of ergot were analyzed by The Penick Pharmaceutical Co. They found that the fresh guinea grass ergot exhibited none of the usual activities of ergot and considered it probable that none of the ergot alkaloids were present.

The results with guinea pigs and the laboratory tests for alkaloids are in agreement with field observations that no undue number of cattle abortions occur during the ergot season. In all probability, guinea grass ergot is nontoxic to animals.

The following grasses were observed infected with ergot:

Andropogon intermedius (Host) Beauv. var. *acidulus*, *Melinis minutiflora* Beauv., *Panicum maximum* Jacq. var. Gramalote, *P. maximum* Jacq. var. Guinea, *P. maximum* Jacq. var. Fine-leaf, *P. maximum* Jacq. var. Broad-leaf, *P. maximum* Jacq. var. Borinquen, *Paspalum conjugatum* Bergius, *Paspalum dilatatum* Poir., *P. hartwegianum* Fourn., *P. humboldtianum* Fluegge., *P. millegrana* Schrad., *P. notatum* Fluegge, *P. plicatulum* Michx., *P. virgatum* L., *Setaria geniculata* (Lam.) Beauv.

ESTABLISHING A COOPERATIVE NATIONAL RESEARCH PROGRAM TO DEVELOP PRACTICAL METHODS AND EQUIPMENT FOR WEED CONTROL

Field Test With 2,4-D. A. J. Loustalot, H. J. Cruzado, and T. J. Muzik.

It is a well-known fact that 2,4-D does not affect established or mature grasses such as those used for lawns. This information on weed control was put to practical test when a relatively large area of the station grounds was planted with sod of Manila grass (*Zoysia matrella* (L.) Merr.) to establish a lawn. The results of this experiment demonstrated that lawns of sodded Manila grass can be established rapidly and with a minimum of weeding if the area is treated with sodium 2,4-D at the time of or soon after planting.

2,4-D on Sugar Content. A. J. Loustalot, H. J. Cruzado, and T. J. Muzik.

Several instances have been reported in which preharvest application of 2,4-D to cane foliage increased the sucrose content. Experimental data were obtained on the effect of preharvest sprays with 2,4-D on sugarcane in Puerto Rico. Twelve plots were sprayed with 0.2-percent isopropyl ester of 2,4-D in water at the rate of 90 gallons

per acre. Eleven days after treatment, 6 treated plots and 6 check plots were harvested and the cane was sent to the mill for grinding and chemical analysis of the juice; and 25 days after treatment the remaining 6 treated and 6 check plots were harvested. Under the conditions of this experiment spraying sugarcane with 2,4-D prior to harvest had no consistent or significant effect in increasing the sugar content. The average sugar content of the juice from untreated cane was slightly but not significantly higher than that from treated cane.

MOVEMENT OF 2,4-D IN SOIL. T. J. Muzik, A. J. Loustalot, and H. J. Cruzado.

In a previous report an experiment was described in which the movement of sodium 2,4-D in soil following different amounts of rainfall was studied. The data obtained in that experiment showed that the sodium 2,4-D did not move beyond the surface inch of soil even when an inch equivalent of rainfall was applied following the herbicide application. The results were the same in both dry and saturated soil. It was thought that perhaps salt formulations other than the sodium compound may behave differently in their movement in the soil, hence the experiment was repeated, using the diethanolamine salt of 2,4-D. The data obtained in dry and wet soils showed that diethanolamine 2,4-D did not move beyond the first inch and little, if any, moved beyond the first half inch of soil, regardless of the amount of rainfall applied or whether or not the soil was saturated or relatively dry.

These data are in close agreement with those obtained with sodium 2,4-D and in direct contrast to the results obtained in a similar experiment carried out earlier on the same soil type with sodium trichloroacetate (TCA). The TCA moved downward in the soil in direct relationship to the amount of rainfall following its application. The fact that the sodium and diethanolamine salt of 2,4-D are not leached to any appreciable extent beyond the surface half inch of soil is of considerable interest in carrying out preemergence practices on this soil type.

FIELD TESTING OF HERBICIDES. T. J. Muzik, G. W. Luvisi,[5] and H. J. Cruzado.

Twenty-nine experimental herbicides were tested on an area of mixed weed infestation. Combining 2,4-D with various vitamins apparently did not reduce the selectivity or increase the potency of 2,4-D. Combining 2,4-D with triiodobenzoic acid and alpha-naphthalene acetic acid apparently did not reduce the selectivity or increase the potency of 2,4-D. The action of TCA on grasses can be improved by combining with 2,4-D and/or a contact killer. On mixed infestations, the greatest total residual kills were obtained by 2,4-D contact killer combinations. A combination of diisopropyl dixanthogen at 2 pounds per acre and 2,4-D isopropyl ester at 2 pounds per acre was particularly outstanding. In all cases where combinations of 2,4-D and other herbicides were used, the resultant kills were greater and longer lasting than would be expected from such a combination. There was no significant difference in total kill when a compound was applied in oil and when applied in an oil in water emulsion. The

[5] National Aluminate Corp., Chicago, Ill.

straight oil formulation gave a quicker kill but the water emulsion eventually was as effective.

STATISTICAL EVALUATION OF HERBICIDES. T. J. Muzik, G. W. Luvisi,[5] and H. J. Cruzado.

For preliminary testing of new chemicals as herbicides, it is desirable to study them under field conditions, because results of greenhouse and laboratory tests are not always conclusive. A technique was developed which is practical for the preliminary screening of herbicides.

A stand of a weed species, as pure as possible, is divided into a Latin square design, with each plot 3 feet long by 3 feet wide. The herbicidal solution is sprayed within a plywood frame 18 inches high to prevent any of the spray drifting to adjacent plots. To obtain stand data a frame 24×24 inches divided into 36 compartments each 4×4 inches in size is laid in the center of each 3×3 feet plot. After treatment every compartment which contains one or more green blades is given a value of 1. Thus the control or untreated plot theoretically always has a value of 36. The results are then analyzed statistically. This method permits a measurement of partial kill which gives the investigator leads for further experimentation.

The efficiency of three levels of sodium trichloroacetate (TCA) alone and in combination with diisopropyl dixanthogen was compared on Bermuda grass (*Cynodon dactylon*), using the statistical evaluation technique. In every case the combination of diisopropyl dixanthogen with TCA was more effective than the TCA alone, at 30, 60, or 100 pounds per acre. Diisopropyl dixanthogen alone produced only a contact kill. To determine whether this method would also be applicable to other types of grasses, malojillo grass (*Panicum purpurascens*) was used as the test plant in a similar experiment. Malojillo was chosen because a large area of a nearly pure stand was available and also because it grows in clumps, whereas Bermuda has a more creeping type of growth.

Malojillo seemed to be more sensitive to TCA than Bermuda grass. Significant results were obtained even at the rate of 30 pounds per acre. Malformations of leaves, stems, and nodes were very pronounced, especially under the higher levels of TCA. The leaves were crumpled and twisted and the stems and nodes were swollen to about twice the normal size.

The TCA-diisopropyl dixanthogen combination was only slightly more effective than the TCA alone, except at the lowest rate. The addition of 8 pounds of diisopropyl dixanthogen to 30 pounds TCA per acre gave a marked increase in kill. This may be due to the sensitivity of the malojillo to TCA which is so great that the additional effect of the diisopropyl dixanthogen was not apparent at the higher levels of application. This method of evaluation of herbicides is apparently effective on malojillo as well as on Bermuda grass.

Experiments were conducted to determine the effectiveness of diisopropyl dixanthogen alone and in combination with 2,4-D as a preplanting and pre-emergence treatment. The results of these experiments show that diisopropyl dixanthogen increases the effectiveness of TCA on Bermuda grass and under some conditions it increases the activity of 2,4-D on broadleafs, but not on grasses. It has no apparent value as a pre-emergence or preplanting weed control treatment when used alone.

NUTGRASS CONTROL WITH METHYL BROMIDE. A. J. Loustalot, H. J. Cruzado, and T. J. Muzik.

The control of nutgrass (*Cyperus rotundus* L.) by fumigation with methyl bromide was investigated. The data obtained showed that as little as one-half pound of methyl bromide per 100 square feet was sufficient to eradicate nutgrass tubers to a 9-inch depth if the soil was plowed and a good gas-tight cover was maintained over the treated area for 48 hours. Plots treated in this way were entirely free of nutgrass 1 year later and were covered with other vegetation.

In carrying out the foregoing methyl bromide fumigation experiment, data were obtained on the distribution of nutgrass tubers at 3-inch intervals to a soil depth of 9 inches. Most of the tubers occurred in the first 3 inches of soil. Approximately one-fourth occur in the interval from 3 to 6 inches and only 3 to 5 percent occur in the 6- to 9-inch depth. A few tubers are found occasionally below 9 inches but seldom do they occur below 12 inches. The number of dead tubers found in untreated soil ranged from 5.6 to 14.5 percent.

NUTGRASS PHYSIOLOGY. T. J. Muzik and H. J. Cruzado.

Studies on nutgrass have shown that inhibition of sprouting in the lowest tubers is probably controlled by hormones produced by the upper tuber or tubers. Experiments in which the rhizome was killed by dipping in boiling water showed that the inhibitor traveled in the living tissue and that it is possible to free any specific tuber from inhibition without affecting the other tubers in the same chain. 2,4-D was translocated in the living tissue and accumulated in sufficient amounts to kill the second tuber in 9 weeks at an average distance of 5.0 centimeters in these experiments.

Natural or applied auxins failed to inhibit sprouting when the chains were inverted or planted horizontally, whereas in vertical chains the inhibition was very strong, showing that natural or applied auxins do not move against gravity in the rhizomes. Polarity within the tuber is less easily upset and the apical bud always sprouts first. Light stimulates sprouting of tubers, presumably through destruction of the inhibitory hormones.

Histological examination showed that the morphogenesis of the tuber, rhizome, and basal bulb is basically similar. Tuber formation may be divided into four stages: (1) Elongation of the rhizome from a bud, (2) cessation of growth, (3) expansion of the region just back of the rhizome apex, and (4) new growth of rhizome, often from same terminal bud, thus forming a series of tubers separated by varying length of rhizome.

Formation of the basal bulb is very similar except that the expansion occurs in the apical region. The leaves in the terminal bud itself thicken and enlarge to form a bulb and it is from this bulb that the shoot emerges. Whether bulbs or tubers are formed seems to be conditioned largely by the amount of light. Near the surface, bulbs are formed; beneath the surface, tubers are formed. The length of the rhizome is partially conditioned by light.

PHYSIOLOGICAL STUDIES. A. J. Loustalot.

Although 2,4–D is now widely used as a herbicide for controlling broadleaf weeds there is little or no published information as to how or why this compound produces its effects on plants. A series of experiments was initiated to determine the effect of 2,4–D on the photo-

synthetic activity of leaves of velvetbean (*Stizolobium deeringianum* Bort.).

The rate of carbon dioxide assimilation of all plants in a given experiment was determined for a period of several days prior to treatment to establish the "normal" relationship between test and check plants. After this period of calibration the test plants were treated wih 2,4–D and the determination of the rate of photosynthesis was continued until the test leaves disintegrated or the assimilation of CO_2 ceased. Four experiments were conducted involving different concentrations of 2,4–D and different methods of application.

The data obtained in these experiments show clearly that 2,4–D lowers the rate of photosynthesis of susceptible plants. The decreases in the rate of photosynthesis occurred before any outward signs of injury appeared. The data also showed that the degree of depression of photosynthesis was proportional to the amount or concentration of 2,4–D applied.

VANILLA

VANILLA PATHOLOGY. T. Theis and F. A. Jiménez.

In testing vanilla species for disease reaction the following technique proved of value. Two-node cuttings of *Vanilla fragrans* with single roots were used for inoculation. Some of them were injured by removing a thin 1-inch slice from the root. All the cuttings were then inoculated by dipping the roots in a spore-mycelium suspension of the root-rot fungus. They were then planted in pots of sterilized decomposed grass mulch. Four isolates of the fungus were tested. Regardless of isolate, the roots of all injured inoculated plants were diseased to the node in 7 days. A number of the uninjured inoculated plants became diseased, but at the end of 3 weeks three of them were still uninfected. This result is typical of previous inconsistent results. Similar results were obtained in a second trial except that at the end of 3 weeks eight of the noninjured inoculated plants remained uninfected. The check plants in both trials remained healthy. The results and observations in this experiment substantiate the idea that root injury in the presence of vanilla root rot increases the susceptibility of the plant to infection.

The technique for inoculation of vanilla with root rot was used to test the comparative disease reaction of the following species of vanilla: *Vanilla fragrans* (Salisb.) Ames, *V. pompona* Schiede, *V. phaeantha* Reichenb., and *V. barbellata* Reichenb. f. Under the conditions of this experiment, neither *V. pompona* nor *V. fragrans* exhibited any resistance to root rot. From general field observations, it is doubtful whether the fact that two *V. barbellata* plants are resistant indicates conclusive evidence of resistance. A further study of clonal lines, therefore, may be worth while. *V. phaeantha*, on the other hand, has a good resistance to the disease. When the mulch was washed away from the roots of these plants, it was apparent that the root tip had become infected. However, the disease was arrested and new uninfected branch roots had developed from the original root. Throughout the experiment the *V. phaeantha* plants remained dark green, turgid, and appeared healthy. This test further strengthens the field observations of the resistance of *V. phaeantha* and may be useful in screening hybrids of *V. fragrans* × *V. phaeantha* for root-rot resistance.

The mulch in which diseased vanilla plants were growing was treated with chloropicrin and formaldehyde to try to eradicate the root-rot fungus, *Fusarium batatatis* var. *vanillae* Tucker. Before treatment, the newly proliferated aerial roots became diseased soon after they entered the mulch. After fumigation, the new roots did not become diseased but grew throughout the mulch. Such plants continued good growth. The success or failure of this technique depends upon the extent that disease has affected the plant. Those plants in which the stems were considerably shriveled failed to root. Nonshriveled, still-vigorous plants rooted and developed a vigorous disease-free root system.

A comparison of the rooting ability of plants in different stages of vigor was made. Cuttings of *Vanilla fragrans* were taken from the following types of plants: (1) Those with no functioning roots, leaves light green in color and flaccid, stems shriveled; (2) those with no functioning roots, leaves dark green and turgid, stems firm and round; and (3) those with good root system, leaves dark green and turgid, stems firm and round.

The cuttings were immersed in 0.5-percent calcium hypochlorite solution for 5 minutes and planted in sterilized cocopeat. The cuttings from the badly diseased plant (1) all deteriorated. The others (2 and 3) rooted well. These results indicate that it may be possible to fumigate the mulch around a plant in the early stages of root rot, induce rooting, and thus enable the plant to make a recovery without appreciable loss in vigor.

Observations from an experiment to determine the effect of fumigation and sanitation on vanilla root rot indicate that the treatments had a beneficial effect on the rate of initial shoot growth. Cuttings immersed in hypochlorite solution and planted in mulch made significantly better root growth than that obtained in untreated cuttings. A cocopeat-grass mixture provided the most favorable medium for initiating growth.

Mulch Studies. T. Theis and F. A. Jiménez.

In an experiment to determine the effect of different types of mulch on vanilla growth and production the following types of mulch were tested: Grass, tropical kudzu, grass and tropical kudzu, cocopeat, cocopeat and commercial fertilizer, cocopeat and grass, and cocopeat and tropical kudzu.

The plots containing tropical kudzu or a mixture of kudzu with another mulch were the most difficult to maintain because the kudzu decomposed so quickly that it had to be replaced frequently. In an effort to reduce the frequency of application the mulch was chopped finely before it was added. This made it possible to add greater amounts.

Shortly after the use of chopped mulch was started, a number of plants looked poorly. Examination showed that the underground parts were rotted. Temperature measurements made 11 days after the addition of the mulch showed that fermentation was still actively going on. The compacting due to chopping the mulch apparently restricted freedom of aeration and caused accumulation of toxic by-products of fermentation of which heat is only one example. This difficulty can be corrected by allowing the fresh mulch to stand in a pile for several weeks or by placing the fresh mulch around the edge

of the bed and gradually moving it over toward the plant after it "matures."

VANILLA CURING. J. Garciá Rivera and R. H. Hageman.

The effect of storing ground vanilla beans temporarily at high oxygen levels prior to drying them, on the quality of the cured product, was investigated. Killed and ground blossom-end-yellow beans were subjected to 21-, 30-, and 60-percent oxygen levels for 3 days; freshly ground beans were tested the same way. At the end of each day duplicate air samples were withdrawn from each treatment and analyzed for oxygen and carbon dioxide. After the beans had been given the oxygen treatments they were placed in open dishes and oven-dried at 50° C. to about one-fourth of their original weight. After they had been conditioned for 1 month in closed containers, standard extracts of the beans were prepared and analyzed for vanillin content and quality.

The data in general show that the oxygen absorption and the carbon dioxide evolution increased as the oxygen level increased. At the 21-percent oxygen level almost all of the available oxygen was used during the first day. At the 30-percent level about 96 percent of the available oxygen was used in 3 days, and at the 60-percent level only 70 percent of the available oxygen was used in the 3 days. There was no significant difference between any of the treatments in vanillin content or quality.

There was no difference in the quality of killed or fresh beans stored at oxygen levels higher than normal, for 3 days prior to drying them. However, when beans were stored at oxygen levels below 21 percent, their quality deteriorated.

An experiment was conducted for the purpose of trying to establish the optimum oxygen concentration for conditioning vanilla. Blossom-end-yellow beans were finely ground and then oven-dried at 50° C. to about one-fourth of their original weight. The dried beans were placed in suction flasks and divided into three groups of eight duplicate samples each. The following oxygen levels were established for duplicate samples of each group: 0, 5, 10, 20, 30, 40, 50, and 60 percent. The three groups were conditioned in a closed cabinet for 1 month, 2½ months, and 5 months, respectively.

The vanillin content was not changed significantly by any of the treatments. All the extracts prepared were classified as "fair." The oxygen absorbed with few exceptions increased as the oxygen level increased. The CO_2 evolved increased as the oxygen level and the time of exposure increased. During the conditioning period oxygen does not seem to affect vanillin content or the quality of vanilla.

In previous experiments the total oxygen absorbed and the CO_2 evolved by ground vanilla beans were measured by analyzing the atmosphere in which the samples were stored before and after treatment. Oxygen was not replaced as it was used, so that the total oxygen available for reaction diminished as time passed. Since the volume of oxygen absorbed and the CO_2 evolved were not equivalent, the total pressure also diminished with time. It was thought worth while to replace the oxygen used, so that the available oxygen and total pressure could be maintained constant, and at the same time to measure the rate at which the oxygen was used.

For this purpose a constant oxygen supply apparatus was devised. With this apparatus the rate and total oxygen absorbed and the total

CO_2 evolved by grinding fresh and dried vanilla beans were measured. The data obtained show that nearly 50 percent of the total oxygen was absorbed during the first day of exposure. The total oxygen absorbed in all cases was about eight times the total carbon dioxide produced, indicating that only a small portion of the oxygen absorbed was utilized in respiration. The vanillin content of the fresh beans was about 2.42 percent and that of the dry beans 3.08 percent, showing that more vanillin was produced during the drying period. The extracts of all treatments were considered fair but none were outstanding. With few modifications the apparatus devised for measuring the rate of oxygen absorption can be used to carry on further fundamental investigations on the rate of oxygen absorption in the curing of vanilla.

The relation of browning to oxygen absorption was investigated. Blossom-end-yellow beans were autoclaved for 15 minutes at 250° F. and 15 pounds pressure, and an equivalent amount was not autoclaved. The beans in both lots were then ground and divided equally into three 500-ml. flasks which were connected individually to a constant oxygen supply. A record was kept of the oxygen absorbed by the samples for a period of 10 days, after which the atmospheres of all the samples were analyzed for CO_2 and O_2. Part of each sample was used to prepare "wet" extracts and part was oven-dried and then conditioned for 1 month and extracts were then prepared from them.

The beans not autoclaved absorbed a mean of 216 ml. of O_2 and produced a mean of 24 ml. of CO_2; those autoclaved absorbed 80 ml. of O_2 and produced 201 ml. of CO_2. The autoclaved beans remained yellowish green during the treatment and on drying turned very light brown.

The vanillin content of the beans not autoclaved was 4.25 percent, whereas that of autoclaved beans was only 0.64 percent, which is approximately the amount present in fresh beans. The autoclaved beans gave extracts that were very poor. There is apparently some relationship between the browning of the beans and the absorption of oxygen, and the absorption of oxygen is apparently determined by the presence of enzymes that were killed by autoclaving. The hydrolysis of glucovanillin to glucose and vanillin was also inhibited by the autoclaving, probably because the enzyme emulsion present in the green beans and responsible for this reaction was also destroyed.

In previous work it was shown that light and possibly temperature promoted the absorption of oxygen by ground vanilla beans. An experiment was carried out to study the effect of temperature alone on oxygen absorption prior to drying.

Samples of freshly killed ground vanilla beans were placed in Erlenmeyer flasks and connected to a constant oxygen supply at room temperature, at 38° C., and at 48° C.

A daily record was kept of the oxygen absorbed over a period of 16 days, after which the atmospheres over the samples were analyzed for CO_2 and O_2. The beans were oven-dried and conditioned for 1 month.

For the first 5 days the beans at 38° C. absorbed oxygen at a greater rate than those at the other temperatures. The beans at 48° absorbed oxygen at a lower rate from the start. The beans at room temperature or approximately 28° absorbed oxygen at a somewhat lower rate than those at 38° for the first 5 days, but after that period they absorbed a considerably larger amount.

A temperature of more than 38° C. is apparently detrimental for the absorption of oxygen, probably because the enzymatic system is affected adversely by the higher temperatures. The volume of CO_2 produced was essentially the same regardless of treatment, indicating that the larger differences in oxygen absorbed were due to a process other than respiration. There were no significant differences in the vanillin and total phenol content of beans given different treatments.

The effect of light on oxygen absorption was also investigated. Samples of killed ground vanilla beans were placed in Erlenmeyer flasks and connected to individual oxygen supplies. Some of the samples were placed in a dark room, and the other three were irradiated continuously with two fluorescent lamps at a distance of 2½ feet from the flasks. The beans under continuous irradiation absorbed nearly twice as much oxygen as those kept in the darkness. Throughout the experiment the temperature was nearly constant and at all times was the same in both treatments. The results of this experiment indicate that light promotes absorption of oxygen by vanilla beans. The significance of this fact is not well understood at the present time but the information may be helpful in interpreting the steps involved in the curing of vanilla when additional data are available.

Some exploratory experiments were initiated with the idea of obtaining a better understanding of the role of oxygen absorption on the curing of vanilla. This included drying vanilla beans under an atmosphere completely devoid of oxygen and comparing the product to a control dried in air. Vanilla beans were also kept in their own juice for a long time, in the complete absence of oxygen, and the product thus obtained was compared with a control treated the same in all other respects but kept in air.

At the same time the above experiment was carried out another test was run. Beans from the same lot were placed into suction flasks. Some of the flasks were evacuated, replaced with pure nitrogen, and connected to a constant nitrogen supply. Other flasks were connected to a constant oxygen supply. The beans were maintained under these conditions in their own juice for 11 days. Daily record was taken of the gaseous changes in all samples. The beans were them autoclaved and dried, and extracts were prepared and analyzed for vanillin and total phenols.

The nitrogen-treated beans remained completely green while kept under nitrogen and turned to a greenish-yellow color on drying. The beans dried faster and did not develop the sticky character that all ground vanilla develops on standing in air.

Although the vanillin and total phenol content in these beans was actually higher than in the controls, the controls had a better aroma. This indicates that the controls developed some aromatic and flavoring substances that the beans dried without oxygen did not develop. Extracts prepared from nitrogen-treated beans were lighter in color than the controls and inferior in aroma and taste. After 18 days of standing under nitrogen, the ability to absorb oxygen and turn brown was still latent in these beans.

Although this study has been mainly of an exploratory nature, the data obtained from it are of sufficient interest to suggest certain ideas as to the steps involved in curing vanilla: (1) Vanillin and other

phenols are produced in ground vanilla beans in the absence of oxygen; (2) ground vanilla beans kept under nitrogen do not turn brown, but they retain the ability to absorb oxygen and turn brown after 18 days; (3) although the percentage of vanillin and total phenols in nitrogen-treated beans was actually higher than in the controls, the latter had a better aroma; and (4) extracts prepared from the control were better in quality than those prepared from nitrogen-treated beans.

An experiment was carried out to compare sunlight and oven heat as sources of energy in the drying of vanilla beans, and to determine if there was any appreciable difference between the final products. Blossom-end-yellow vanilla beans were "killed" by dipping in water at 65° C. for 3 consecutive minutes. Some of the beans were then ground in a food chopper and thoroughly mixed. Some of the ground and some of the whole beans were placed separately in an oven at 50° to be dried slowly to a moisture content of about 30 percent. The other ground and whole beans were dried in sunlight in the usual manner, also to about 30-percent moisture.

Oven-dried whole beans had a better appearance than sun-dried whole beans. They were more flaccid and oily, and had a large amount of crystalized vanillin. For all practical purposes the extracts prepared from the whole and ground beans were uniform. It was not possible to distinguish one from the other. The time required to cure the beans in the ovens was appreciably less than that required for those cured in the sun. The ground beans in both treatments were easier to handle. The product obtained in drying the beans in ovens was as good as that obtained by drying them in the sunlight. In case of cloudy or rainy weather, ovens can be used to cure beans without affecting the quality.

An experiment was carried out to determine how vanilla beans could be cured with the least possible handling and to evaluate the quality of the finished product. Blossom-end-yellow vanilla beans were finely ground in a food chopper and uniformly distributed into jars covered with inverted funnels, which allowed moisture to evaporate but prevented rain from falling into the containers. The containers with the beans were placed in the sun and left there night and day for 12 days. The beans were then conditioned for 1 month and standard extracts were then prepared and analyzed for vanillin and total phenols. The percentage of vanillin found was 3.2 and of phenols 7.1. These are more or less the same percentages found in average beans cured in this laboratory. The standard sun-curing method requires continuous handling of the individual beans for 6 or 8 days. In the present experiment labor was reduced to a minimum by allowing the beans to remain in the container until ready for conditioning. The extracts prepared from these beans were as good or better than those prepared from beans cured in the conventional way.

BAMBOO

Distributions. F. Montalvo Durand.

In cooperation with the Puerto Rico Industrial Development Co., 12,252 linear feet of bamboo was distributed to local manufacturers of bamboo articles, and to private individuals. In addition 530 pounds of bamboo branches were sold.

PROPAGATION STUDIES. F. A. McClure [6] and F. Montalvo Durand.

Experiments were conducted to induce branch cuttings of bamboo to produce rooted plants. Branch cuttings in each of three age groups (1, 2, and 3 years) were prepared for eight species of bamboo with the following exception: For *Bambusa textilis* McClure, no material over 2 years of age was included. The cuttings were defoliated and any branches arising from the upper nodes were trimmed to leave a few viable buds capable of producing leafy twigs. The cuttings were planted in a propagating medium of cocopeat and fine sandy loam.

With the exception of *Bambusa ventricosa*, all cuttings which had neither germinating buds nor living plants attached to them were dead when the beds were cleared 1 year later. All age groups of the cuttings of three species, *B. longispiculata* Gamble ex Brandis, *B. tuldoides* Munro, and *Dendrocalamus strictus* failed to root. The older cuttings of *B. textilis*, *B. ventricosa* and *Gigantochloa apus*, gave better results than the younger ones, whereas for *B. tulda* Roxb. and *Bambusa* sp., cuttings in the middle age group, gave the best yield.

The principal problem was the slowness of the basal buds of the cuttings to break their dormancy. A relatively high percentage of the cuttings of *Bambusa ventricosa* which were planted in unshaded beds was still in a living condition. The basal buds on a number of the cuttings began to germinate a full year after they were planted.

COFFEE

AGRONOMIC STUDIES. A. Rodríguez Cabrera and R. Vázquez.[7]

Yields of the Columnaris variety of *Coffea arabica* L., from Java, and the West Indian variety were compared for the seventeenth crop year in 1950. The Columnaris variety yielded at the rate of 12.95 hundredweights of marketable coffee per acre, whereas the West Indian variety yielded only at the rate of 7.05 hundredweights per acre. This difference was highly significant. The average yield per acre of the Columnaris variety for the 17-crop period is about twice that of the West Indian variety.

WEATHER

Rainfall recorded at Mayaguez, Puerto Rico, for the last 6 months of 1950 was 50.62 inches or 0.88 inch above the 52-year average of 49.73 inches. For the first 6 months of 1951 a precipitation of only 15.60 inches was recorded, which was 13.82 inches below the 53-year average of 29.42 inches. The precipitation for the first 6 months of 1951 was the lowest recorded for this period since the year 1899. The total rainfall for the fiscal year 1950–51 was 66.22 inches, far below the 52-year average of 79.15 inches.

The mean temperature for the fiscal year 1950–51 was 77.33° F., which was 0.05° above the 52-year average of 77.28°.

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[7] Members of the staff of the Agricultural Experiment Station of the University of Puerto Rico.

TABLE 1.—*Weather conditions at the Federal Experiment Station, Mayaguez, P. R., during the fiscal year 1950–51*

Month	Precipitation [1]			Temperature [2]				
	Total	Greatest in 24 hours	Days with 0.01 inch or more	Mean maximum	Mean minimum	Mean	Maximum	Minimum
1950	*Inches*	*Inches*	*Number*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*
July	6.90	2.15	16	90.6	66.9	78.8	93	65
August	13.21	2.54	15	90.7	68.3	79.5	93	66
September	11.85	2.12	18	90.2	68.9	79.6	94	67
October	9.69	3.40	18	89.2	68.2	68.1	95	65
November	4.79	1.86	10	87.4	67.9	77.7	90	65
December	4.18	2.51	8	84.6	64.1	74.4	86	61
1951								
January	1.30	.62	8	83.5	62.9	73.2	86	59
February	.10	.04	3	84.7	62.0	73.4	87	58
March	.26	.22	2	85.8	62.2	74.0	90	59
April	5.70	2.07	9	90.6	65.4	78.0	96	62
May	3.70	.76	14	90.7	69.6	80.2	95	66
June	4.54	1.08	12	91.4	69.7	80.6	95	67

[1] 52-year average: July, 10.44 inches; August, 10.99 inches; September, 10.79 inches; October, 9.26 inches; November, 5.67 inches; December, 2.58 inches.

52-year average: January, 1.99 inches; February, 2 inches; March, 3.61 inches; April, 4.93 inches; May, 8.16 inches; June, 8.73 inches.

[2] 51-year average—Mean temperature: July, 79.0°; August, 79.4°; September, 79.4°; October, 79.1°; November, 77.6°; December, 76.0°.

52-year average—Mean temperature: January, 74.6°; February, 74.7°; March, 74.9°; April, 76.1°; May, 77.8°; June, 78.8°.

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HUME, E. P. Growing avocados in Puerto Rico. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 33, 53 pp., illus. 1951.

HUME, E. P. Some ornamental shrubs for the Tropics. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 34, 151 pp., illus. 1951.

JONES, M. A., and ARRILLAGA, NOEMI G. The production of lemon-grass oil. Puerto Rico (Mayaguez) Fed. Expt. Sta. Bul. 50, 41 pp., illus. 1950.

PLANK, H. K. Studies of factors influencing attack and control of the bamboo powder-post beetle. Puerto Rico (Mayaguez) Fed. Expt. Sta. Bul. 48, 39 pp., illus. 1950.

PLANK, H. K. Insecticidal properties of some plants growing in Puerto Rico. Puerto Rico (Mayaguez) Fed. Expt. Sta. Bul. 49, 17 pp. 1950.

WINTERS, H. F. Cinchona propagation. Puerto Rico (Mayaguez) Fed. Expt. Sta. Bul. 47, 26 pp., illus. 1950.

An article also appeared in a Department periodical:

THEIS, T. Fusarium wilt of tomatoes in Puerto Rico. Plant Disease Reporter 34: 213. 1950.

The following articles were published by the station staff in periodicals outside the Department:

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LOUSTALOT, A. J., and FERRER, R. The effect of some environmental factors on the persistence of sodium pentachlorophenate in the soil. Amer. Soc. Hort. Sci. Proc. 56: 294–298. 1950.

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WARMKE, H. E. Studies on pollination of *Hevea brasiliensis* in Puerto Rico. Science 113: 646–648. 1951.

WINTERS, H. F. Preventing damping-off in cinchona seedbeds. Trop. Agr. [Trinidad] 27: 123–126. 1950.

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